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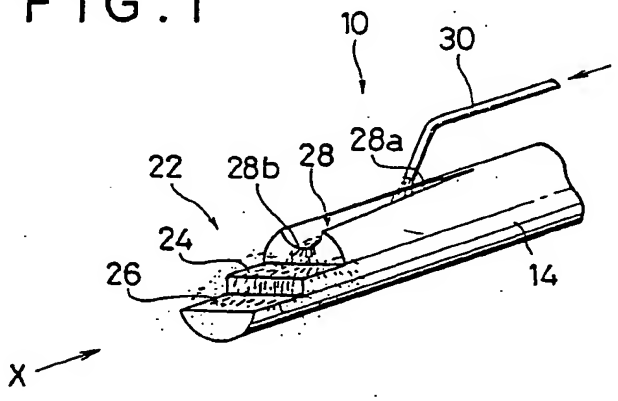
(54) Ultrasonic atomizing vibratory element.

(57) An ultrasonic atomizing vibratory element (10) comprises a elongated shank (14), and the tip of the elongated shank is formed with an edged portion (22) having at least one flat portion (24) which is formed stepwise. Liquid fuel is supplied from a pipe (30) to the flat portion (24) of the edged portion (22) along a groove (28) in the shank, and the liquid is atomized at the edged portion by ultrasonic vibration applied to the shank (14).

FIG. 1



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ULTRASONIC ATOMIZING VIBRATORY ELEMENT

Technical Field

The present invention relates generally to an ultrasonic atomizing apparatus, and particularly to a vibrating element for use with an ultrasonic atomizing apparatus for atomizing liquid either intermittently or continuously. Such an element may be effectively used with (1) automobile fuel injection devices such as electronically controlled gasoline injection valves and electronically controlled diesel fuel injection valves, (2) gas turbine fuel nozzles, (3) burners for use on industrial, commercial and domestic boilers, heating furnaces and heating devices, (4) industrial liquid atomizers such as drying atomizers for drying liquid materials such as foods, medicines, agricultural chemicals, fertilizers and the like, spray heads for controlling temperature and humidity, atomizers for calcining powders (pelletizing ceramic), spray coating devices and reaction promoting devices, and (5) liquid atomizers for uses other than industrial ones, such as spreaders for agricultural chemicals and antiseptic solution.

Background Art

Pressure atomizing burners or liquid atomizers have been heretofore used to atomize liquid in the various fields of art as mentioned above. The term "liquid" herein used is intended to mean not only liquid but also various liquid materials such as a suspension, a solution or the like. In the injection nozzles used on such spray burners and the liquid atomizers, the liquid is atomized by virtue of the shearing action between the liquid injected from the nozzles and the ambient air (atmospheric air). Accordingly, in order to atomize the liquid supplied, it is required to increase the liquid supply pressure, resulting in making the liquid supplying facility such as pumps, piping and the like complicated and large-sized ones.

Further, regulation of the flow rate of injection is effected by varying either the pressure of the liquid supplied or the area of the nozzle injecting port. However, the former method provides poor liquid atomization at a low flow rate (under a low pressure), as a remedy for which air or steam has additionally been used on medium-sized or large-sized boilers to aid in atomization of the liquid fuel supplied. And therefore apparatus become more and more complicated and enlarged.

On the other hand, the latter method requ an extremely intricate structure of nozzle whic troublesome to control and maintain.

To improve the defects of such prior art ir tion nozzles, attempts have been made to im ultrasonic waves to a liquid material as the li material is injected from the injection port of injection nozzle under pressure.

However, the conventional ultrasonic liquid jection nozzle cannot be used in circumstar which require a large amount of atomized li because it has extremely small capacity for verization.

As a result of extensive researches and exp ments conducted on the ultrasonic liquid atomi mechanism and the configuration of the tas vibrating element so as to accomplish atomiza of a large amount of liquid, the present applic have found that by providing an edged portio the end portion of an ultrasonic vibrating elem and supplying liquid to the edged portion in a form, a large quantity of liquid can be atomize the edged portion, and have proposed an ultrasc injection method and an injection nozzle on basis (see European Patent Application 85302674.8).

The present invention relates to improveme in the ultrasonic atomizing apparatus descri above, and particularly to improvements in vibrating element for use with the atomizing paratus.

Accordingly, an object of the present inven is to provide an ultrasonic atomizing vibratory ment which is capable of accomplishing satis torily either continuous or intermittent liquid pp

Another object of the present invention is provide an ultrasonic atomizing vibratory elem which is capable of stably and effectivly atomiz liquid either in a large amount or a small amo and therefore providing an extremely large tu down ratio as well as mixing the atomized liq with air for combustion, particularly in fuel inject nozzles for use in domestic heating boilers, turbines, automobiles and the like.

A further object of the present invention is provide an ultrasonic atomizing vibratory elem which is capable of accomplishing stable atomi tion without fluctuating the states of atomizat (flow rate and particle size) of the supplied liqu In particular, the element of the present invent may be suitably used for a horizontally dispos combustor.

Summary of the Invention

The present invention provides an ultrasonic atomizing vibratory element comprising an elongated shank and an edged portion which has at least one flat portion stepwise formed at the tip of the elongated shank, the flat portion of said edged portion being supplied with liquid to atomize said liquid.

Brief Description of the Drawings

One way of carrying out the present invention will now be described in detail by way of example with reference to Fig. 1 of the accompanying drawings which is a fragmentary perspective view of an embodiment of an ultrasonic atomizing vibratory element in accordance with the present invention, FIG. 2 being a sectional view of a conventional ultrasonic atomizing apparatus which will be described in detail, by way of comparison.

Detailed description with reference to the accompanying drawings.

With reference first to Fig. 2, the conventional apparatus, namely, a fuel atomizer 1 for use with a kerosene heater used as a burner for a domestic heater, for example, is provided with a vibrating element 10 in a sideways position. The vibrating element 10 includes a body portion 12 positioned on the right in this embodiment, an elongated, cylindrical shank 14 of the vibrating element having a diameter smaller than that of the body portion 12 and a transition portion 16 connecting the body portion 12 and the shank 14. The body portion 12 is provided with an enlarged diameter flange 18 which is supported by a holder 20, and the vibrating element 10 is secured to a heater body (not shown) through the holder 20.

The tip of the vibrating element 10, that is, the tip on the left of the shank 14 in this embodiment is formed with an edged portion 22. Further, one or more fuel-supplying pipes 30 are disposed adjacent to the edged portion 22 of the shank 14, which feed the fuel to the edged portion 22. The fuel supplying pipes are supplied with the liquid fuel from a fuel supplying source (not shown) through external supplying lines (not shown). The flow and flow rate of fuel are controlled by supplying valves (not shown) disposed in the external supplying lines.

With the construction described above, the vibrating element 10 is continuously vibrated by an ultrasonic vibration generating means 100 operatively connected to the body portion 12. Accordingly, liquid fuel is supplied through the lines, the supplying valves and the supplying pipes 30, to the edged portion 22 where the fuel is atomized and outwardly injected.

The edged portion 22 of the vibrating element 1 is usually formed either with four annular steps having progressively increased diameters or with a plurality of annular steps having equal diameters as shown.

The atomizing apparatus having such construction operates extremely effectively. However, the present inventors have found that the atomizing apparatus such as fuel injection nozzles for use with a boiler, a gas turbine or an automobile, and the like in which the flow rate and thus supplying speed of fuel varies in response to the running load has various drawbacks.

Particularly, with the construction of the atomizing apparatus of the type as shown in Fig. 2 in which a vibrating element is horizontally disposed, and constructed as shown in Fig. 2, at an increased flow rate of fuel supply a part of the fuel may fall in drops without being fed to the edged portion, or the particle size of the liquid being pulverized may be increased.

The occurrence of such phenomena causes incomplete combustion resulting in increasing hydrocarbon, carbon monoxide and soot in the exhaust gas. On the other hand, at a low flow rate of fuel the mixing of fuel and air for combustion is insufficiently effected resulting in lowering combustion efficiency and increasing hydrocarbon, carbon monoxide and soot in the exhaust gas similar to the above-mentioned.

The ultrasonic atomizing vibratory element according to the present invention and shown in Fig. 1 will now be described in detail with reference to Fig. 1.

While the present invention may be effectively used in various applications as mentioned above, in the present embodiment, the present invention will be described as being used as a fuel atomizer for a kerosene heater as explained in connection with Fig. 2. Fig. 1 merely shows an edged portion 22 at the tip of the vibratory element of the atomizer.

According to the present invention, the edged portion 22 of a vibrating element 10 is formed with a plurality of flat portions 24 and 26 which are stepwise formed at the tip of the vibrating element 10 (or the edged portion 22) and progressively reduced in the height of step in the direction from right to left in Fig. 1 in the present embodiment. The shape of the edged portion 22 as seen in the direction indicated by arrow X is suitably a circular shape but is not limited to such a shape. In the present embodiment, the edged portion is formed with two flat portions, namely a first flat portion 24

and a second flat portion 26 but the configuration of the edged portion 22 is not limited to this two step configuration and may comprise one step or more than two such steps.

Further, while the flat portions 24 and 26 are separately formed in horizontal planes in the present embodiment, they may be formed in planes slanted in any direction other than horizontal, if desired. Further more, respective flat portions may be slanted in different directions.

Further, a shank 14 of vibrating element 10 is formed with a groove 28 in the outer periphery of the shank 14 which groove receives fuel from a fuel supplying pipe 30. The groove 28 is adapted to guide the fuel along the shank to the first stage flat portion 24. The groove 28 is progressively enlarged in cross-section from an upstream portion 28a which receives the fuel discharged out of the fuel supplying pipe 30 to a downstream portion 28 b whereat the fuel is discharged to the flat portion 24. Preferably, the bottom surface of the groove is inclined downwardly in the direction from the fuel receiving portion 28a to the fuel discharging portion 28b, to facilitate the flow of the fuel along the groove.

Further, the groove may be of a U-shaped or V-shaped cross-section.

With the construction of vibrating element described with reference to, and as shown in, Fig. 1, the fuel which is supplied to the shank 14 of the vibrating element may be guided by the groove 28 to flow efficiencly to the first flat portion 24. The fuel which is supplied to the first flat portion 24 may be spread over the first flat portion resulting in increasing the contacting area of the fuel and the edged portion. The fuel may be atomized at the flat portion 24 and its peripheral edges. The surplus fuel which is not atomized at the first flat portion 24 flows from the first flat portion to the second flat portion 26 to be again spread over the second flat portion 26 and to be atomized at the second flat portion and its peripheral edges. Thus, the present invention accomplishes an increased efficiency of pulverization and cooling of supply liquid.

In addition according to the present invention, it is possible to accomplish consistent liquid atomization and eliminate the trouble that the fuel supplied to the edged portion 22 in the prior art Fig. 2 construction falls in droplets.

Advantages of the Invention

With the construction as herein described according to the present invention with reference to Fig. 1, the ultrasonic atomizing vibratory element can stably and efficiently atomize either a large amount of, or a small amount of, liquid at the flat portion(s) formed in the edged portion, and res ing in providing a large turn down ratio and el nating the problem of falling of the liquid droplets.

Further, it is possible to accomplish sta combustion and reduction of hydrocarbon (H carbon monoxide (CO) and soot in exhaust ga in fuel injection nozzles for use with fuel atomiz for kerosene heaters, boilers, gas turbines, uomobiles and the like, to a large extent.

In addition the vibratory element of Fig. 1 accomplish consistent liquid atomization in there is no substantial change in the condition atomization (flow rate and particle size), so particularly the vibratory element of Fig. 1 r effectively be used in a horizontal combustor.

Claims

1. An ultrasonic atomizing vibratory elem comprising an elongated shank and an edged p tion which has at least one flat portion stepv formed at the tip of the elongated shank, said portion of said edged portion being supplied v liquid to atomize said liquid.

2. An ultrasonic atomizing vibratory elem according to claim 1, wherein said flat portion is a substantially horizontal plane.

3. An ultrasonic atomizing vibratory elem according to claim 1 or claim 2, wherein said sh is formed with a groove for guiding the liquid said flat portion of the edged portion.

4. An ultrasonic atomizing vibratory elem according to claim 3, wherein said groove is p gressively enlarged in section in the direction fr a portion to receive the liquid to a portion to scharge the liquid to the flat portion and the bott surface of the groove is inclined downward, in direction from said liquid receiving portion to s liquid discharging portion.

5. An ultrasonic atomizing vibratory element claimed in any preceding claim, wherein the edg portion comprises more than one step.

6. An ultrasonic atomizing vibratory element claimed in claim 5, wherein the steps both lie horizontal planes.

7. An ultrasonic atomizing vibratory element claimed in claim 5, wherein the steps lie in plan intersecting one another.

FIG. 1

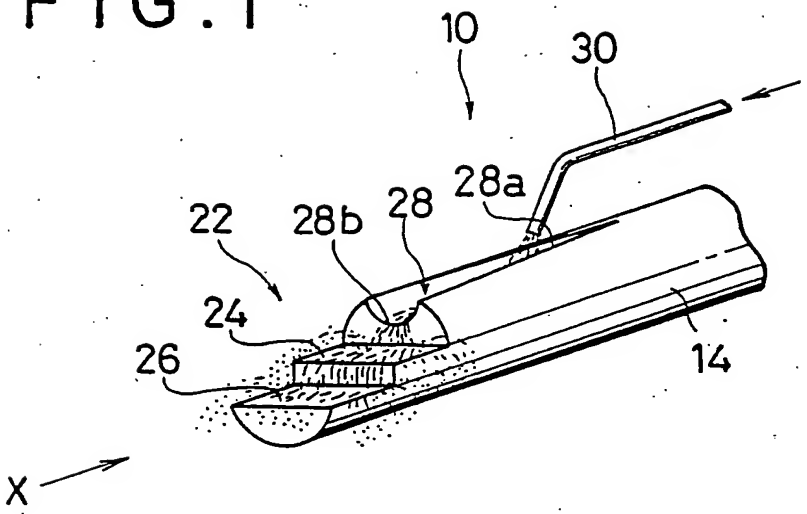

FIG. 2
(PRIOR ART)